

DEEP SPACE DEEP OCEAN

Aramco Technology and
Operational Excellence Forum

Session 2: Electric Power in Sea & Space

Deep Dive 3: Advanced Technologies & Materials Track

Tuesday, April 7, 2015, 3:45pm-5:15pm

The Woodlands, TX

Power Panel

- Richard Voight Subsea Power Mgmt. & Distribution
 - Senior Executive Engineer, Subsea Systems, INTECSEA
- Frank Davies Space Power Mgmt. & Distribution
 - Senior Project Engineer, NASA Johnson Space Center
- <u>Daniel Winslow</u> *Downhole/Subsea Power Gen. & Storage*
 - Senior Technical Advisor, Halliburton
- Koorosh Araghi Space Power Generation & Storage
 - Technology Manager, NASA Johnson Space Center
- <u>Jeff George</u> *Moderator*
 - Advanced Power Project Manager, NASA Johnson Space Center

Panel Purpose & Goals

Purpose: For Electrical Power...

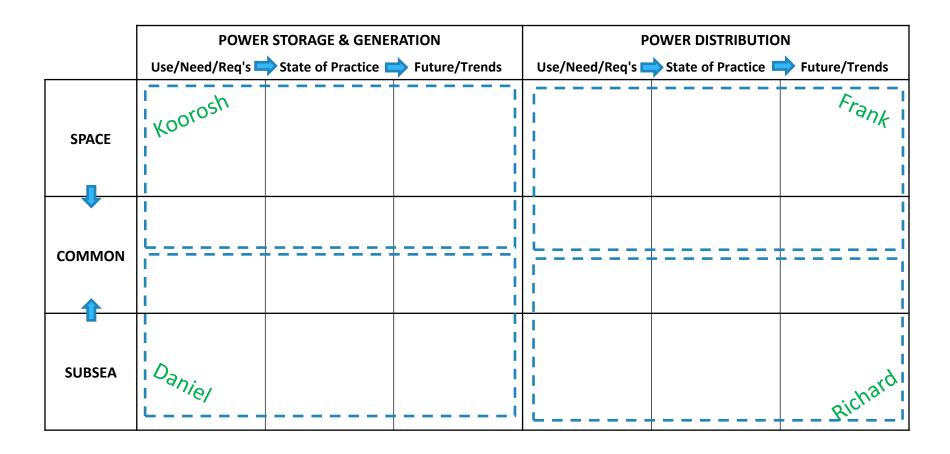
- "Deep Space, Deep Ocean: Exploring <u>Crossover Technologies</u> in the Space and Energy Sectors."
- "Both the oil and gas and aerospace industries operate in <u>harsh</u>, often unexplored <u>environments</u> requiring unique solutions for <u>safety</u> and <u>reliability</u>."
- "...go on a "deep dive" to analyze <u>common challenges</u> and set the stage to solve these challenges through technology <u>collaboration</u>."

Goals:

- 1. Survey Electrical Power Gen/Stor/Mgmt/Distr for Subsea & Space
- 2. Identify Commonalities (crosswalk chart)
- 3. Panel Engagement, Dialogue
- 4. Audience Engagement, Questions, Dialogue & Input

Finding Common Ground

ELECTRIC POWER IN SEA AND SPACE



Agenda

 Intro & Problem Statement 	Jeff	5 min
 Subsea Power Mgmt & Distr 	Richard	15 min
 Space Power Mgmt & Distr 	Frank	15 min
 Subsea Power Gen & Stor 	Daniel	15 min
 Space Power Gen & Stor 	Koorosh	15 min
Crosswalk Chart	Jeff	5 min
 Audience Q&A, Discussion 		<u>20 min</u>
		90 min

Comparing Electric Power in Sea and Space

	POWER GENERATION & STORAGE			POWER MANAGEMENT & DISTRIBUTION		
	Use/Need/Req's 📦 State of Practice 📦 Future/Trends			Use/Need/Req's State of Practice Future/Trends		
SPACE	ISS, Orion. Hot <u>&/or</u> Cold (-150 to +150°C). Reduced Gravity. Radiation. Dusty Moon/Mars. Low Mass!	1's-10's-250 kWe. Recharg. Batteries. Fuel Cells. Solar Photovoltaics. Radioisotope Generators.	PEM & Solid Oxide Fuel Cells. Li-lon advancement. Better solar cells & array deployment. Nuclear power & propulsion.	ISS, Orion. Hot <u>&/or</u> Cold (-150 to +150°C). Reduced Gravity. Radiation. Dusty Moon/Mars. Low Mass!	Silicon semicond. 28, 120, 160 Vdc. 10's m transmission. Copper wire. Redundancy.	Higher powers: 100'skWe-MWe's. New SiC, GaN semi. Aluminum wires. 300+ Vdc.
соммон	Harsh Environ's. Remote Ops. Safety & Reliability.	Hi operating temps. Lith. prim. batteries. Li-lon rechg. batt's.	High energy density recharg. batteries. Fuel cells.	Safety & Reliability. Harsh Environ's. Remote Ops, Deploy, Reconfig. Volum. efficiency.	Copper wire. Redundancy. DC-DC converters, inverters, variable speed drive elec's.	DC Power. Increased Safety & Reliability. Partnering / Knowledge Sharing.
SUBSEA, DOWNHOLE	Subsea: Power Grid Downhole: Directional Drilling, Logging/NucMagRes , Wet, Mud, HiPress, HiTemp.	Topside Diesel or Gas Turbines. BHA: 10'sW-1kWe. Primary Batteries. Mud turboalt. 200°C Formations	230°C Formations. 150°C Rechg. Batt's. 10's kWe BHAs. Laser or Elec.Disch. Drilling.	Subsea: Production vs. Enhancement, Pumps, Compressors, Flowline heating, Downhole: Wireline		More seafloor funct. LowFreq HVAC (16 2/3 Hz). MedVoIDC (120+ kVdc). Subsea Factory. SWIT (subsea water inj & treatment).